A double depopulation and concentration process in the interior of Spain in the XX century. Migration and "missing birth" in the region of Castile-Leon

I. APPROACH:

The population living in Castile-Leon from 1900 up today, practically has not changed from 2.3 to 2.2 million inhabitants in 2005, while the population in Madrid has multiplied by almost 8, increasing from 775,000 to 6 million inhabitants. Nevertheless, changes in fertility and mortality rates in both regions have been very similar. The number of children per woman has changed from more than 5 to little over 1; the mortality rate in both regions has reduced drastically, doubling life expectancy at birth from 40 years to 80 years; the average survival to motherhood ($L^{coh27.5}$) has changed from 0.47 to 0.97, i.e., where once only half of the female births survived until the average age at motherhood, now almost all survive. The combination of these indicators that define natural growth does not explain what happens in regional demographic dynamics.

Migration appears as the main factor explaining the different trends in populations between Castile&Leon and Madrid. Both populations have undergone intense emigration and immigration processes since the end of the XIX century. Nevertheless, the impact of such processes in one region or another has provided an unequal evolution result for the evolution of these populations.

The analysis of a population's reproduction can be done using different indicators depending on the objectives: total population size, population structure by age and sex, evolution and level of different demographic phenomena (fertility, mortality and migration) being the most common indicators. For generational replacement, the analysis of births is a suitable indicator: it is very sensitive to variations in fertility rates, while at the same time being influenced by changes in mortality and migratory rates, particularly those that concern women at motherhood (15-49 years). It is an indicator that is affected by variations in past demographic dynamics and which conditions the future of that population.

To this end, the first point we want to remark is that traditional demographic indicators that analyse reproduction, Total Fertility Rate (TFR) and Net Reproduction Rate (NRR) are valid only for closed and stable populations (Preston and Wang, 2007). Some authors have tried to solve this problem by incorporating the migration effect; unfortunately, they have a weakness for either considering it as a constant or proposing hypothetical scenarios (Goldstein and Goldstein 1981; De Santis and Livi Bacci, 1997; Ryder 1997; Calot and Sardon, 2001; Smallwood and Chamberlain, 2005; Preston and Wang, 2007).

The TFR indicates the number of children a woman will have in her lifetime if the fertility rates for a particular year remain constant. They assume constant fertility rates and do not take into consideration neither mortality nor migration rates. The NRR refers to the number of female births that will replace their mothers if both mortality and fertility rates remain constant. Although mortality rates are incorporated, they take into account the period or "synthetic" rate, and not that of the cohort or "real" rate, which means that it is an overestimated indicator for periods of declining of mortality. Nor do they incorporate the effect of migration.

Our first objective is to study the impact of each demographic phenomenon in the evolution and process of reproduction, -depopulation of the Castile&Leon region against the concentration process registered for the Madrid region. We have applied the Birth Replacement Ratio (BRR), an indicator of birth replacements that incorporates the effects of all three demographic phenomena. Furthermore, this indicator can constantly analyse the reproduction condition of a population, according to whether the births of a particular year replace their parents ("previous generation").

Secondly, we provide a decomposition of the BRR to measure the impact of each phenomenon (fertility, mortality, emigration and immigration) on replacement of births. Specifically, by taking the birth cohort corresponding to women aged 15-49 (Bt-x), their mortality or survival rate (L^{coh}) and present fertility, the double effect on reproduction caused by these emigration of women can be measured for a particular year: a direct effect due to the loss of women from emigration or gains from immigration and an indirect effect due to their implication in future births. The latter is an aspect not generally taken into consideration when analysing depopulation (or concentration) but one that aggravates the process.

Lastly, using the evolution of replacement factors, a future scenario for these populations is suggested.

II. THE DEMOGRAPHIC CONTEXT IN CASTILE-LEON DURING THE XX CENTURY:

Castile&Leon[1] (appendix 1), nowadays the largest region in the European Union, is characterised by a low population density and a significant rural and agricultural sector. The population in 1900 registered 2.3 million inhabitants living in over 2,800 towns and in the XXI century, there are 2.5 million inhabitants in 2,250 towns that still exist. Nevertheless, nine provincial capitals that had 9% of the regional population in 1900 now comprise 43%, which indicates a huge reduction in rural populations. Up until 1960, the agricultural sector provided 55% of the regional employment although for the last 30 years this has become mainly a services economy (60% employment in 2005) and an industrial economy to a less extent (18%) (Alcaide, 2003; EPA, 2005). Contrarily, Madrid is characterised as being a basically urban and industrial region.

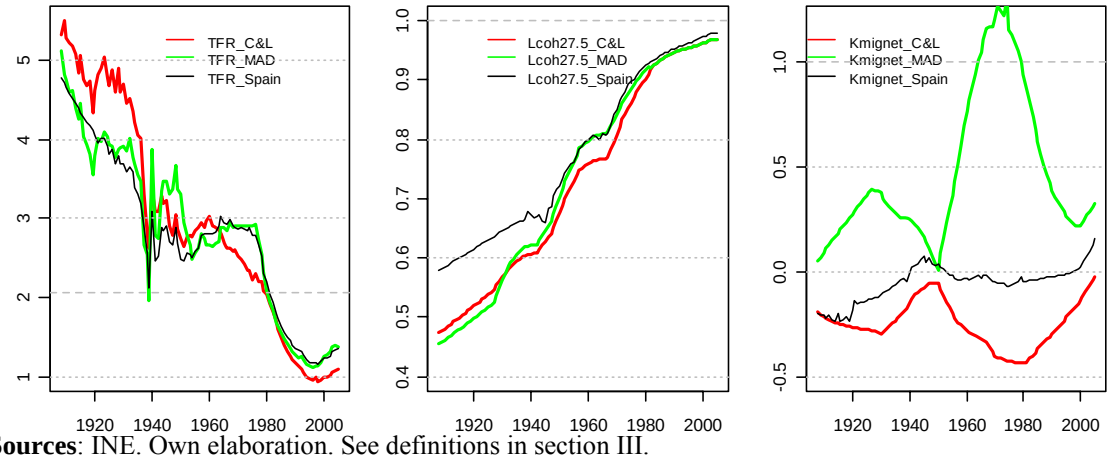
Castile&Leon and Madrid have undergone its own demographic transition as had the rest of Spain throughout the XX century. Fertility rates have suffered a drastic drop to the point of registering one child per woman in the 1990s (Muñoz-Pérez, 1989; Delgado and Lici-Bacci, 1992; Kohler, Billari and Ortega, 2002). Mortality rates have likewise registered a marked drop in all age groups (Reher and Sanz-Gimeno, 2000; Ramiro and Sanz-Gimeno, 2000a, 2000b; Blanes, 2007). Nevertheless, while the Spanish population has multiplied by 2.4 and Madrid by almost 8, the population of Castile has increased by less than 10%.

By comparing tendencies in fertility and mortality rates (figure 1) with population growth (figure 2) we found a lack of correspondence between the indicators. Migration is the main cause of evolution in population dynamics for Castile&Leon and Madrid throughout the XX century.

[1] Castile&Leon is comprised of nine provinces, Ávila, Burgos, Leon, Palencia, Salamanca, Segovia, Soria, Valladolid and Zamora, a total 94,225km^2 (18.6% of the country). In 1900 its population represented 12.4% of the Spanish population and today represents 5.6%.

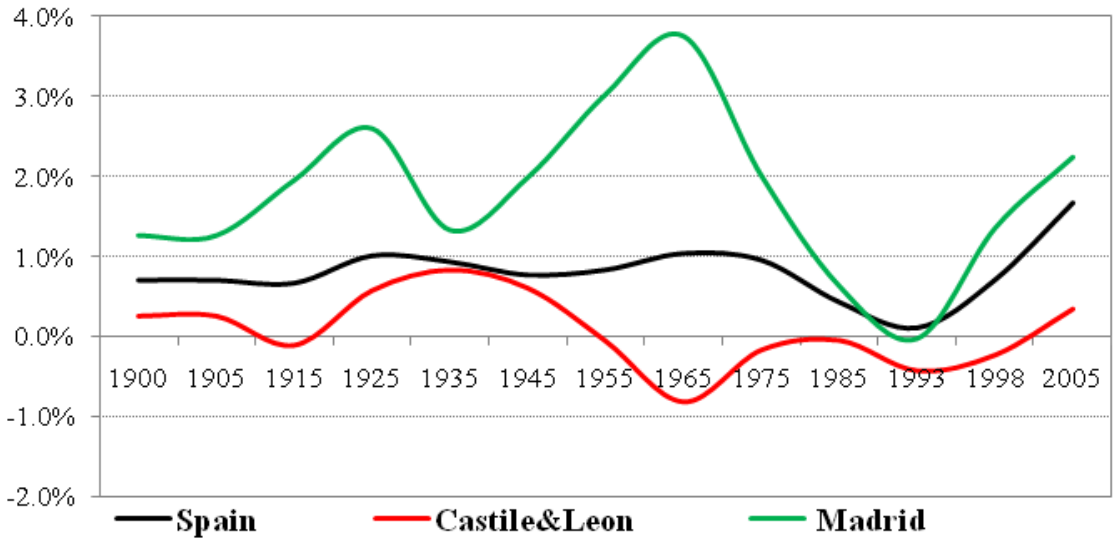
For the period analysed, various migratory phases can be distinguished that affect regional demographic dynamics, phases that are part of the migration taking place in the country as a whole.

Figure 1. Index in Castile&Leon (C&L), Madrid (MAD) and Spain 1908-2005: Total Fertility Rate (TFR), average survival at motherhood ($L^{coh27.5}$) and net migration constant of women between 15-49 years (K^{MigNet})



Sources: INE. Own elaboration. See definitions in section III.

Figure 2. Population Growth Rate (PGR) 1900-2005: Spain, Castile&Leon and Madrid



Sources: Population and Housing Surveys. Various years (INE). Own elaboration.

The *first phase* is marked by the emigration to America. Between 1880 and 1916 around 3 million Spaniards emigrated abroad, mainly to South America (Sánchez-Alonso, 2000) and almost 5 million between 1846-1932 (Arango and Martin, 2005). This population loss is reflected in the female migration constant for Spain in the first decades of the XX century (KNetMig in figure 1).

One of the main causes of this migration was the agrarian crisis of the XIX century (Rodríguez Osuna, 1985), which had a huge impact in Castile. Sánchez-Alonso (2000) places the provinces of Castile&Leon amongst those of greatest migratory intensity (1911-1913 contained 14% of all emigrants). This is reflected in a more pronounced negative migration constant in Castile&Leon than for the rest of the country, although this constant is also affected by internal emigration. Meanwhile,

Madrid shows a positive result, given that international emigration was scarce and especially because it received a high number of internal migrants.

The second phase is the first main period of rural population moving to urban and industrial sectors. This process had its origins in the second part of the XIX century, although it begun to accelerate after the 1920s and continued on until the beginning of the Spanish Civil War (1936). The end of emigration to America and the important economic growth, particularly due to industrial development in Catalonia, Basque Country and Madrid, involved displacements from several rural zones (Silvestre, 2005; 2007). The population of Castile mainly headed for Madrid the closest industrial region and with a strong historical relation (Nadal, 1984; Carbajo Isla, 1985). As a result, the migration constants for Castile&Leon and Madrid reflect opposite trends (figure 1).

The *third phase* comprises the period of the Spanish Civil War and the years following the conflict. It is characterised by scarce migration both internally and internationally (Rubio, 1977; Silvestre, 2002; 2005).

As from the middle of the 1930s until 1950, even when fertility felt considerably, it is nevertheless the period of greatest population growth for Castile&Leon during the XX century. The drop in emigration compensated both the drop in fertility and the higher mortality rates for this period[2].

Even when internal migrations during the Spanish Civil War and post-war were very scarce, in 1950 Castile&Leon presented a negative internal stock of population of 11% according to census data: in certain provinces of Castile&Leon such as Soria and Segovia, this result reached 20% while Madrid registered a positive stock of over 50%. This population was characterised by the concentration in young ages and for a slightly higher rate in female migrant (11.6% against 10.1% of males).

The *fourth phase* in migration began in the 1950s and continued on until the 1980s. This is the period of greatest migration and comprises both internal migration and external migration to different European countries. This is the period of most pronounced negative population growth in Castile&Leon for the XX century while in other regions such as Madrid, the opposite result is given (figure 2).

As the country recovered from the Spanish Civil War and its economic growth accelerated, an important number of populations from very rural regions moved to highly industrialised regions. This is the period that marks the great rural exodus, the de-agriculturalisation of the Spanish economy and subsequent industrialisation-urbanisation. Between 1960 and 1980 migrations in Spain reached unprecedented magnitudes, causing the depopulation of many regions and the concentration of population in only a few (García Barbancho and Delgado, 1988; Cabré, Moreno et al, 1985).

Between 1961 and 1970, 2.1 million people changed region in Spain (Recaño, 2006). Castile&Leon are amongst the 3 regions with the highest negative balance. According to the 1991 census, 34% of population born in Castile&Leon lived outside the region: in first place, in Madrid (13.7%) and to a lesser degree in the Basque Country (7.0%) and in Barcelona (3.8%).

The second migratory component for this period is the emigration to Europe. Between 1950 and 1970, between 2 and 3 million of emigrants in different European countries were registered (Arango and Martin, 2005), with an important presence of female populations in flows (Delgado and García Barbancho, 1988). This fact is

[2] Ortega and Silvestre (2006) estimate a loss of 400,000 births in Spain during the Spanish Civil War and 180,000 between 1940 and 1941, affecting all provinces. Emigrations abroad in those years were very few. With regard to internal migrations, at some moments there was a large number of evacuees in areas such as Madrid 400,000 or in Malaga 150,000 but they recovered in the majority once the war ended.

reflected in the existence of a negative constant for female population from Spain after 1950 and until the 1990s (figure 1).

Castile&Leon has contributed approximately an 8.8% to external Spanish migration between 1960 and 1990, i.e., 200,000 inhabitants (López Trigal and Prieto Sarro, 1993), when its population in 1981 represented less than 7% of the total and which indicates a higher incidence than the national average. This flow of emigrants was concentrated in young and adult ages and of mainly rural origins.

The crisis of 1973 caused European Economic Community countries to close their borders to Spanish workers and marked the end of the exodus abroad (Rapado, 1983; Muñoz-Pérez and Izquierdo, 1989; López Trigal and Prieto Sarro, 1993; Blanco, 1993). As from 1975, the return of Spaniards from countries such as the German Federal Republic exceeded departures from Spain to the same country (Muñoz-Pérez and Izquierdo, 1989). However, for 1980, it was estimated that the number of Spaniards or people of Spanish origin (nationalised) that lived permanently in Germany, Switzerland and France is around 800,000 (Muñoz-Pérez and Izquierdo, 1989) and according to Arango and Martin (2005) there are presently two million Spaniards living outside Spain.

The *fifth phase* comprises the 1990s and the first years of the XXI and it is characterised by intense exterior immigration.

Up until the 1980s, the number of resident foreigners in Spain was few and concentrated in tourist areas of the Mediterranean, in Madrid and Barcelona, predominantly from the European Community (Muñoz-Pérez and Izquierdo, 1989; Blanco, 1993). Nevertheless, the continued economic development of Spain after 1985 explains the change in Spanish migration tendencies (Blanco, 1993), without forgetting more recently, the effects generated by the drop in fertility in the labour market. As from the middle of the 1990s, Spain ceases to be a country of emigrants to become one of immigrants (figure 1).

According to data from the National Survey of Immigrants (INE, 2007), of the 4.5 million immigrants registered in 2007, approximately 207,000 arrived between 1987-1991, 320,000 between 1992-1996, increasing to 1,300,000 between 1997-2001 and 1,860,000 between 2002-2007. It is mainly young population, of working age and a fairly balanced distribution of sexes.

Nevertheless, Castile&Leon had one of the lowest immigration population percentages in 2005 (municipal register, INE). In Spain foreigners represented 8.6% of the population, although Castile&Leon only 3.6% (70% are between 20 and 49 years, where 52% are women), while Madrid exceeded 13%. As from 2000, the arrival of immigrants to Castile&Leon has compensated the population loss and after 50 years, a positive population growth has been registered for the region (figure 2).

The migration to other regions and abroad explains the evolution of population in Castile&Leon from 1900. Moreover, as the majority of migrants are young and are at reproductive ages, an indirect effect is added to the direct effect of these departures or arrivals, which is derived from the future impact of births in zones of origin and of destination. Losses are caused by those who leave and for those who will not be born.

To measure the effect generated by both processes, direct and indirect, we propose the application of the Birth Replacement Ratio (Ortega, 2006; Ortega and del Rey, 2006, 2007) to the process of population reproduction in Castile&Leon and Madrid.

III. METHOD AND DATA: THE BIRTH REPLACEMENT RATIOS

The Birth Replacement Ratio is the ratio of births to the size of the mothers' generation at birth; the latter having been weighted according to the current fertility level. We therefore compare current births with births from "the past generation that they replace": cohort births of children (B_t) against cohort births of mothers (BG_t) .The BRR gathers the effects of all three components of demographic dynamics. First it is affected by changes in fertility over time, which affects the number of births (Bt). Secondly, it incorporates the mortality conditions of a generation, taking into consideration the average survival at motherhood ($L^{coh27.5}$). The survival of more or less women at motherhood affects the number of births generated by this cohort of women. Lastly, once the number of female births (B_{t-x}) and cohort mortality (L^{coh}) is known, we can then calculate the population of women at motherhood ($G^{surv}{}_t$ or $G^{NoMig}{}_t$). By comparing the survival mothers with the present mothers (Gt) we obtain the net migration constant and then we can measure the gain or loss of births due to female migration.

The Total Fertility Rate is defined as:

[1]

$$TFR(t) = \Sigma F_x(t)$$

Where $F_x(t)$ is the age-specific fertility rate for age x in year t. This index makes reference to the average number of children that will eventually have a woman throughout motherhood and according to fertility rates in year t. Calot (1984) makes another interpretation of the TFR as an index of transversal replacement by breaking it down as follows:

[2]

$$TFR_t = B_t/G_t;\ \ G_t = \Sigma\left[F_x(t)/TFR_t\right] \,.\, E_x(t)$$

Where G_t is a weighted average of female population exposures; Bt is the total number of births and $E_x(t)$ are the years-woman at risk of having children by age. This formula serves to define the size of the generation of mothers as a weighted average of the female population for the period t, and thus Calot speaks of a period replacement indicator (Calot, 2001). From this interpretation we have the Birth Replacement Ratio which compares births (B) with the size of the generation of mothers also at birth (BG):

[3]

$$BG_t = \Sigma\left[F_x(t)/TFR_t\right] \,.\, B^f(t\text{-}x)$$

The BRR is obtained from the comparison of this number of births of mothers with the current number of births, i.e.:

[4]

$$BRR_t = B_t \,/\, BG_t$$

The theoretical level of replacement is approximately 2.05, which means it replaces both births of mothers and births of fathers[3].

The decomposition of the Birth Replacement Ratio in its components of mortality, fertility, emigration and immigration are based on the relation between G and BG. In particular, in a closed population, where the only component that makes G different from BG is the mortality rate, i.e., in the absence of migrations, we would have the following number of women (G^{NoMig} or G^{Surv}):

[5]

$$G^{NoMig}_t = \sum 0.5[\, L_x(t-x) + L_{x+1}(t-x)] \cdot [F_x(t)/TFR_t] \cdot B^f(t-x)$$

Where $L_x(t)$ is the female cohort life table person-years-lived at age x of the cohort born in year t−x. With this component, we obtain the expected BRR in the absence of migration (RRN^{NoMig}):

[6]

$$BRR^{NoMig} = TFR_t \cdot G^{NoMig}_t / BG_t$$

We assume that fertility rates for those who are missing-emigrated correspond to the average of the province or region of origin.

The comparison between the replacement ratio observed and the expected replacement ratio, allows us to compute a net migration constant $k^{MigNeta}$:

[7]

$$k^{MigNeta} = [BRR_t / BRR^{NoMig}_t] - 1$$

We can also calculate the loss or gain of births per woman (K^{BRR}) due to migration and the total number of "lost" or "gained" births (VarBirth).

[8]

$$K^{BRR}_t = BRR_t - BRR^{NoMig}_t$$

[9]

$$VarBirth = \sum[K^{BRR}_t * G^{NoMig}_t]$$

Furthermore, if we have information regarding the female population by birth place, as occurred in the census years of 1918, 1991 and 2001, it is possible to separate the effects of emigration from the region, immigration from the rest of the country and international immigration:

[10]

$$G_t = G^{Nat}_t + G^{Esp}_t + G^{For}_t$$

Where *Nat* refers to regional or native women, *Esp* refers to women in the rest of Spain and *For* refers to women abroad. These size of mother's generation are obtained by applying the weighted fertility of the female population for period t. Likewise we can determine the proportion of native women who emigrated by comparing G^{Nat} with G^{NoMig}, being G^{NoMig} the women we would expect to find in case of no migration. We refer to this proportion as k^{Emig}.

[11]

$$k^{Emig} = [G^{Nat}_t / G^{NoMig}_t] - 1$$

[3] Value 2.05 results from the *sex ratio* at birth, according to which for every 100 female births approximately 105 males were registered.

Lastly, we can define proportions of G that refer to women from different origins. We refer to these proportions as P. Thus, equation [9] will appear as:

$$G_t = G^{NoMig}{}_t \cdot (1-k^{Emig}{}_t) + G_t \cdot (P^{Esp}{}_t + P^{For}{}_t) \quad [12]$$

Data:

Births by province and capital from 1858 to 2005. Sources: Vital Statistics from Spanish National Institute of Statistic (INE) (see appendix 2).

Total Fertility rate and Fertility rate by age. Sources: Data for each province from INE between 1975-2005. For the period between 1908-1975 the provincial fertility rate has been estimated using the Calot interpretation of the TFR (see appendix 3).

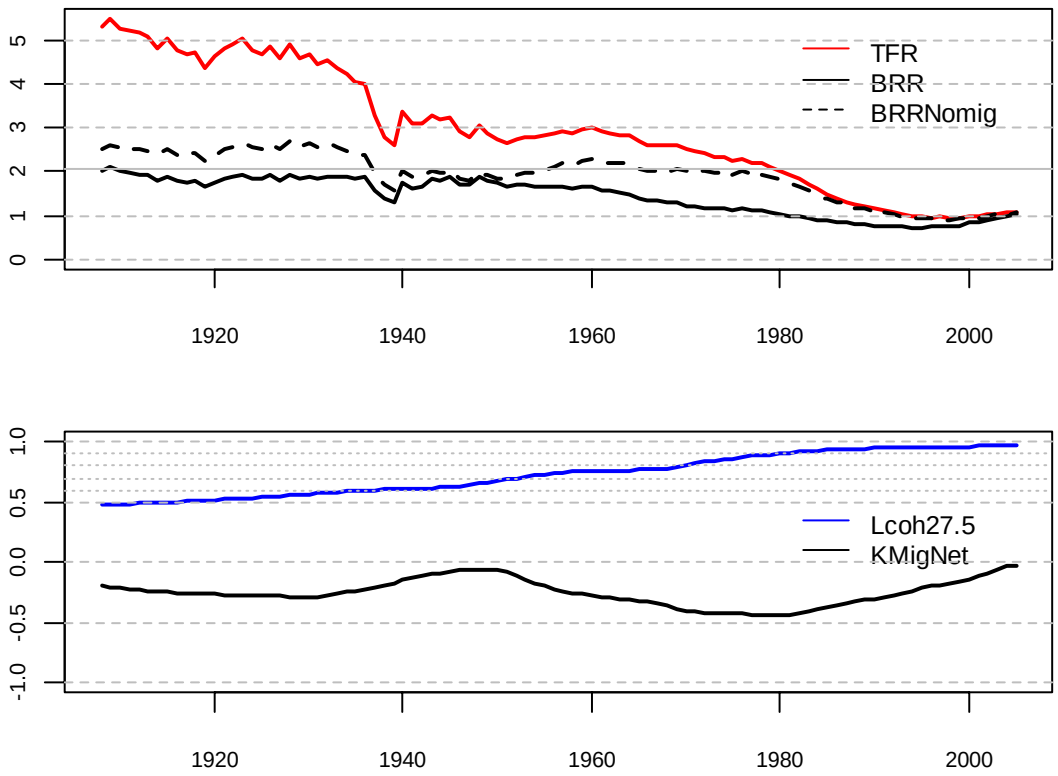
Period life tables. Sources: provincial tables from Dopico and Reher (1998) 1900, 1910, 1920 and 1930; provincial tables from Blanes (2007) from 1960-62, 1965-67, 1970-72, 1975-77, 1980-82, 1985-87, 1990-92, 1995-1997 and 2000-2002. Using the mortality rate for the period, we have estimated the cohort mortality rate (see appendix 4).

IV. GENERATIONAL REPLACEMENT 1908-2005: EFFECT OF EMIGRATION AND IMMIGRATION IN BIRTHS

Variations in fertility, mortality and migration define population growth rate (PGR). Nevertheless this indicator does not reflect the situation of population reproduction, whether concerning depopulation or concentration. For reproduction, the PGR is an aggregated indicator and one that has "no memory": on the one hand it does not reflect each of the demographic phenomena and on the other hand, the on-going evolution does not take into consideration previous variations.

However, the use of the BRR and its decomposition enables the evaluation of the effects of each demographic component and the reproductive situation in relation to whether the number of births replace the previous generation. This indicator as we have pointed out is affected by mortality and migration of women at motherhood in the past and by present fertility.

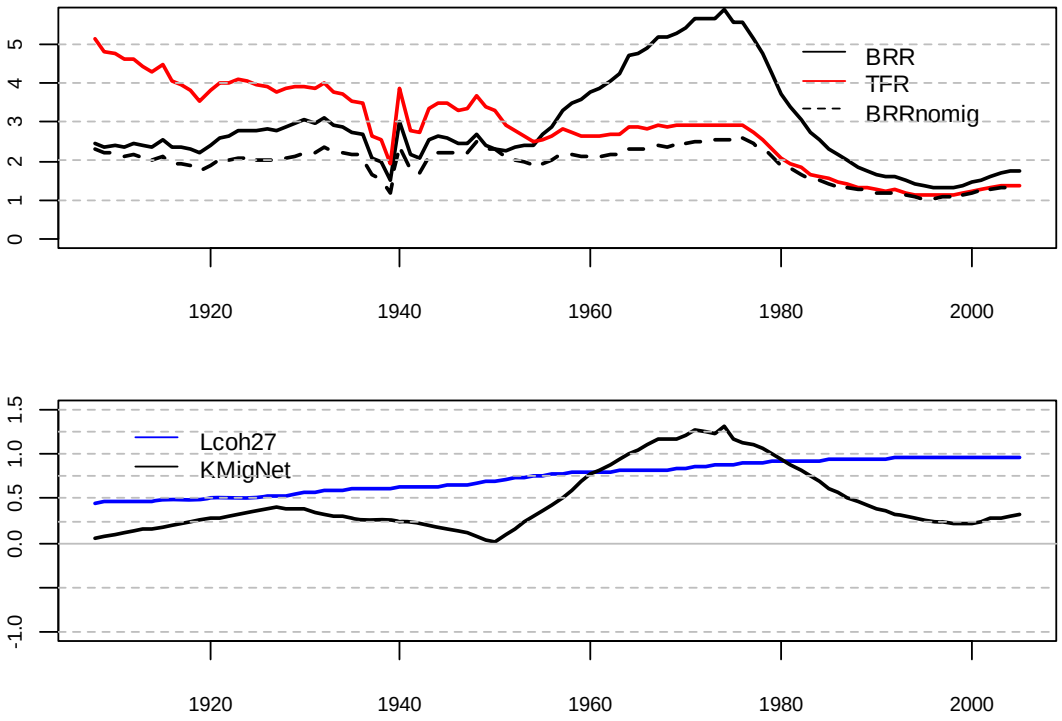
Figure 3: Replacement index in Castile-Leon, 1908-2005



For the region of Castile&Leon, what is first observed is that the BRR for the entire period, except that for 1909, is below the replacement level (2.05), despite the fact that until the 1980s, the TFR is above 2 children per woman (see figure 3). That is, throughout the XX century and for the beginning of the XXI century, yearly registered births never reached to replace the births of generations of parents. However, in Madrid, a traditionally immigrant region, the BRR was well above the theoretical replacement level until the mid 1980s (with the exception of 1938-1939, years of the Spanish Civil War), which means Madrid has easily managed to replace births of previous generations. Even with much lower fertility levels during the second half of the XX

century, the BRR for Madrid has been much higher than the replacement level and has even doubled the fertility level (figure 4).

Figure 4. Replacement index in Madrid, 1908-2005.



In the first part of the XX century, mortality conditioned replacement levels in Castile&Leon. The high mortality rates together with a negative migratory balance in female populations at motherhood explain the low replacement level up until the beginning of the Spanish Civil War. Until 1915, the average survival to motherhood was below 50%, i.e., less than 1 of every 2 girls born in the region survived to the average age at motherhood[4]. The loss of women-mothers in this period was increased by the migration of a large portion of survivors: until the beginning of the Spanish Civil War, the migration constant was less than -20%, with minimums of -30% between 1928-1931. Therefore, despite fertility in this first part of the XX century was above 4 children per woman, the BRR was less than 2, and therefore did not reach replacement levels.

In Madrid, (the main destination for emigrants from Castile&Leon), even when fertility rates were slightly lower than for Castile&Leon and mortality rates higher between 1910-1935, a BRR higher than the theoretical replacement level was registered due to contributions of immigrants. Towards the end of the 1920s and beginning of the 1930s, Madrid provides a migration constant over 30% which shows the important migration of populations between regions during the first half of the XX century. In Madrid, the fertility rates (TFR) and replacement rates (BRR) are much closer than in

[4] It is worth noting the importance of taking the cohort mortality instead of that of the period of mortality drop phases. For example for 1930 the $L^{coh27.5}$= 0.57 while $L^{per27.5}$= 0.70, i.e., mortality in the latter has been highly under-estimated.

Castile&Leon, given that the negative impact of mortality in replacement levels is corrected by migration.

The expected replacement indicator (BRR^{Nomig}) in Castile&Leon for these years would have been above the theoretical replacement level (figure 3 and table 1), unlike what would have happened in Madrid for certain years (figure 4 and table 2).

The decline of fertility in Castile&Leon at the beginning of the century did not affect the BRR, given that it was compensated by the increase in survival at motherhood which reached 60% at the start of the conflict. Only the period of the Spanish Civil War entailed an alteration of the BRR in the first part of the XX century, as a consequence above all of the reduction in fertility given that the Spanish Civil War hardly affected female mortality rates. The migration of women between 15-49 years during this period was scarce. Opposite tendencies are found in the migration constant for Castile&Leon and Madrid: in the first case, net losses are reduced and in the second net gains are reduced (figure 3 and 4).

In the second part of the XX century, replacement in Castile&Leon was marked by a sharp decrease in fertility and by the impact of migration. This caused a permanent drop in BRR despite the increase in survival, which was below 1 as from 1980. A BRR of 1 means that births of those years only replaced half the births from the generation of their parents. In practice, this means a reduction to half the amount of births from previous generations[5]. In Madrid after 1950, and despite the fertility decline, replacement rose until it reached values close to 6 by the mid-1970s due to the impact of migration. The BRR for certain years is double the TFR, which indicates a sharp increase in the number of births during these years in relation to past births. Thus, while in the 1970s the number of births dropped to half in Castile&Leon in relation to previous generations, they doubled in Madrid (figure 5).

On the one hand, there was a gradual decline of fertility from 2.8 in 1950 to less than 1 in the mid-1990s[6]. On the other hand, almost right until the 1980s, given the high decrease in mortality, it would have reached the theoretical replacement in the absence of migration, as observed in the expected replacement values in Castile&Leon. The difference between BRR and BBR^{Nomig} is the effect generated by female migration at motherhood in the number of births in the region (figure 3).

Migration beyond the region gradually increased after 1950. This is clearly reflected in the female migration constant until the 1980s, when losses began to slow down. Between 1971 and 1983 the K^{MigNet} exceeded -40%, i.e., 2 of every 5 women between 15-49 had left the region. This situation implies that for every birth registered in Castile&Leon, another was practically "lost" due to the emigration of their mothers (difference between BRR and BRR^{Nomig}).

Yet again, Madrid, unlike Castile&Leon, registered migration constants higher than 1 for particular years, despite the fact that the rest of the country had losses due to emigrations to Europe as already mentioned. In other words, Madrid had more than double of expected women according to previous female births and mortality conditions (figure 4). Of the 5.9 births registered in 1974 in the BRR, 2.55 were from women from Madrid and 3.33 from immigrant women. The contribution from migration in the first part of the 1980s allowed the BRR to maintain itself above the replacement level, despite fertility levels being below 2.1 children per woman.

[5] Births for 1980 were 33,000 while those for 1950 were 68,000.

[6] In Castile&Leon there is a sharp drop in fertility, both due to the decrease in the number of children per woman, and due to the structure effect generated by the emigration of women at motherhood in the previous years (Agüero and Olano Rey, 1980).

In the last period, and after the mid-nineties, a slight recuperation in fertility and replacement began both in Castile&Leon and in Madrid, due to a large extent to foreign immigration. In the first place, fertility rates in Castile&Leon slightly rose from 0.94 children per woman in 1998 to 1.03 in 2005. This increase is the result of both the recovery of native fertility and the arrival of foreign women with higher fertility levels. In second place, the negative migration constant for women at motherhood lowered considerably, due to both a decrease in internal emigrations and to women arriving from outside the region. In 2001, compared to previous census, there was a greater presence of women at motherhood that were not born in the region (table 3) and especially women born outside Spain (5%). This percentage has continued to rise in following years in step with the rise in the international flow. In Madrid, migration from abroad was compensated by contributions made by internal migration which represented 53% women at motherhood in 1981 to 20% in 2001, while foreign mothers went from representing 3% to 14%.

Nowadays, in conditions of very low fertility and very high survival rates, the migratory factor is the main determinant of the replacement process and reproduction in Castile&Leon. As from 2000, with the average survival at motherhood over 95% and a migratory result at almost zero, fertility and replacement begin to balance out[7] (figure 3 and table 2).

Depending on the impact of migration in each regional area we can calculate "lost" or "gained" births according to arrivals or departures of women at motherhood. This is an "indirect" effect of migration when migrants are women at motherhood. This effect is not generally taken into consideration and it is one that aggravates the depopulation processes in some cases and the concentration of population in others.

In Castile&Leon between 1908-2005, little over 4,300,000 births have been registered but more than 1,200,000 births from the emigration of the female population have not been accounted for; i.e., 27% of births have been lost for this period (figure 5). In Madrid for the same period the number of registered births was 4,774,781, 28% of which (1,333,056) were due to immigration of women. In the mid-70s, the number of registered births in Castile&Leon was identical to the number of births lost as a consequence of female migration. In Madrid for the same period, the opposite occurred: half the registered births were by immigrant women.

The result is that births registered as from 1900 in Castile&Leon has drastically reduced, reaching their maximum in 1903 with over 92,500 while today they are less than 20,000 (figure 6). In Madrid, births have increased from 23,500 to almost 70,000 although this was exceeded in the seventies by over 90,000.

[7] BRR=TFR in conditions of zero mortality impact ($L^{coh27.5}= 1$) and of migration ($K^{MigNet}=0$).

Figure 5: Births registered, and births "lost" and "gained" from migration in Castile&Leon and Madrid, 1908-2005.

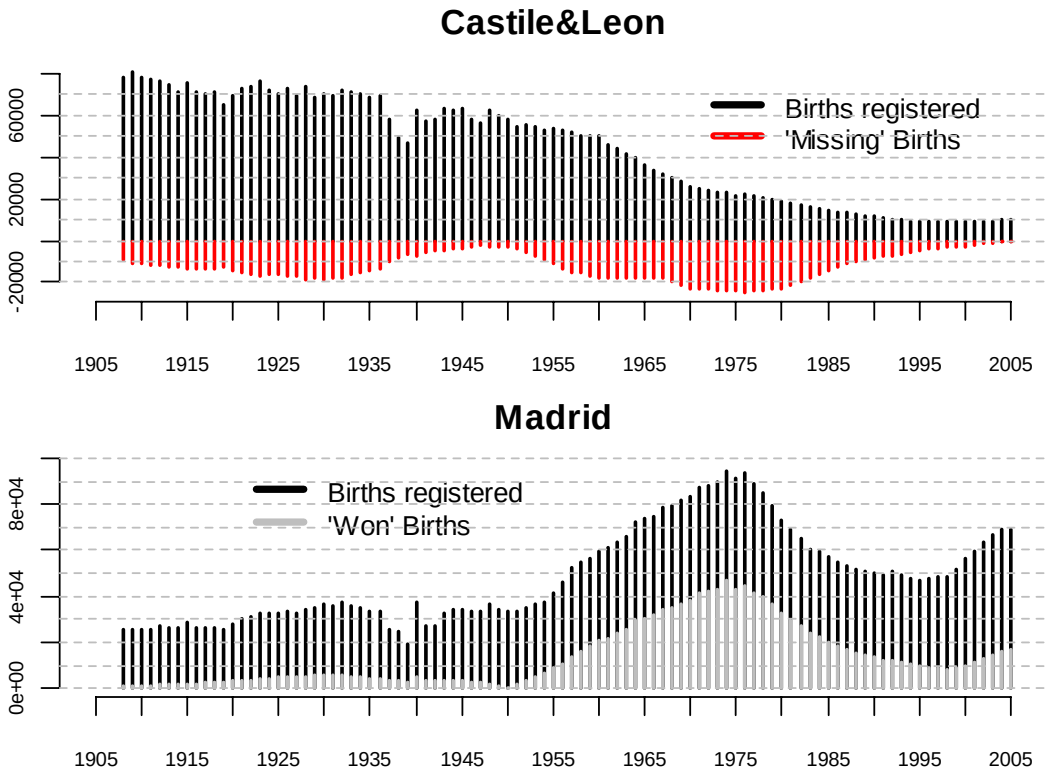
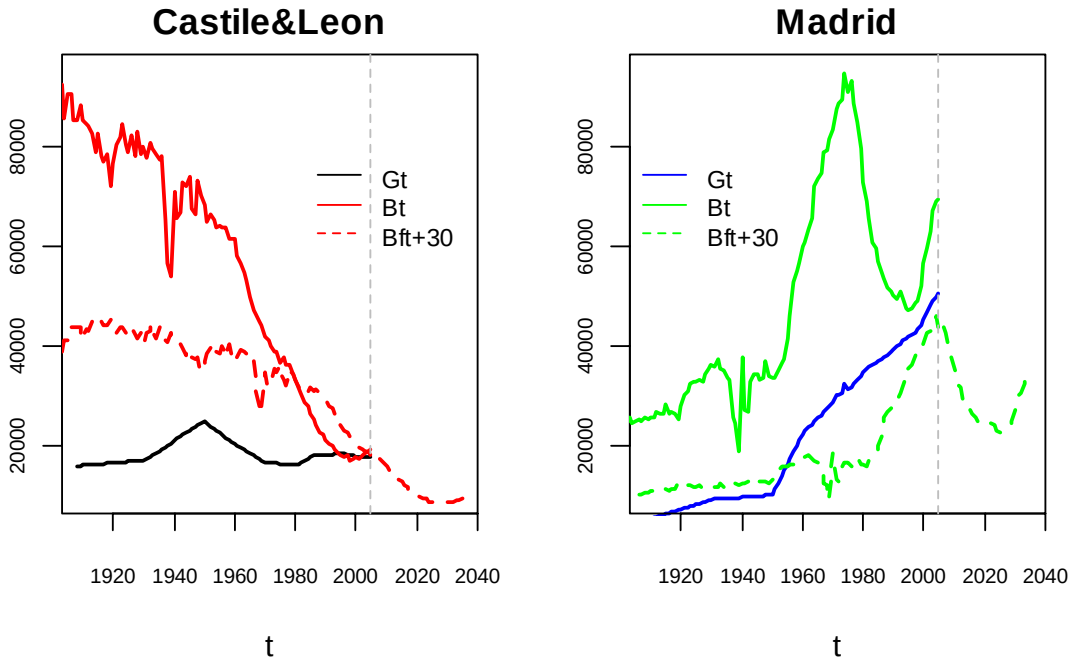


Figure 6: Births (B_t), Females Births (B^f_{t+30}) and Mothers (G_t) in Castile-Leon and Madrid, 1908-2005



Lastly, when proposing a future scenario in the region, one must refer to the present structure of its population and in particular to the female population at motherhood (G_t) both present and expected. Between 1950 and 2005, there has been a 30% drop in the number of women at motherhood living in Castile&Leon. Furthermore, according to past births, the number of women that will be at motherhood (born around

30 years ago, B^f_{t+30}) will decrease in the next few years (figure 6). Thus, given the low fertility level at present, the tendency in the next few years will be a reduction in the number of births. This tendency will only be broken by a sharp rise in fertility, which will be improbable, or by a massive arrival of women at motherhood.

In the case of Madrid, one can also expect a high drop in the number of births in the next few years due to the future drop in the number of women at motherhood (G_t). This number has continually increased since 1950 as a consequence of the high immigration between 1960 and 1980 and recently by the incorporation of female cohorts at motherhood born in the 1970s, the highest number of births in history. Nevertheless the cohorts that will be at motherhood in the next few years (B^f_{t+30}), born after 1980 are much less in number and according to present migration constants, we can expect an important drop in the number of mothers (figure 6). As a result and given that we can not expect a sharp rise in fertility, the increase in the number of births since the end of the 90s seems to have peaked.

V. CONCLUSIONS

Firstly, we would like to emphasise the importance of the replacement indicator and its decomposition to explain the demographic dynamics of a population. The BRR is a replacement indicator that explains the replacement of births according to demographic dynamics both in the present (fertility levels) and past (impact of mortality and migration). Its decomposition serves to evaluate at any given moment the impact of changes in fertility, mortality and to know the impact of migration on replacement. Likewise its robustness enables future scenarios of a population to be proposed.

Castile&Leon and Madrid have undergone the same transition in fertility and mortality in the XX century but the evolution of their volume and structure has been very different: the population of Castile&Leon has practically remained the same, while the population of Madrid has multiplied by 8; nowadays, the population in Castile&Leon below 15 years represents 12% of the total and those over 60 years represent 27.5%, while in Madrid they represent 20% and 19% respectively. However, the BRR clearly shows that the demographic dynamics of Castile&Leon and Madrid have been very different throughout the XX century when the migration effect is taken into account. Castile&Leon has registered replacement levels below the theoretical replacement level while Madrid births, independently of the fertility and mortality evolution, have risen sharply until quite recently and have easily replaced births corresponding to previous generations.

The result is that while Castile&Leon has undergone a sharp depopulation and aging process due to the constant outflow of young population, Madrid has registered the opposite effect: concentration and rejuvenation.

Secondly, the departure or arrival of populations at motherhood generates a double effect in the depopulation or concentration process for a population: direct effects derived from the migration of this population and an indirect effect due to its future effects on births. The migration of women at motherhood means the future gain or loss of births for the region affected.

In Castile&Leon the population that has left the region was mainly young, at working age and from a demographic standpoint, in reproductive ages. This has meant that together with direct losses from those who left (1,175,307 according to the 2001 census) are added indirect losses from births that will not be registered in the region (1,200,000), which is totally the opposite for Madrid. Births have dropped sharply and presently represent less than a quarter of births registered at the beginning of the XX

century. The loss of births implies the inability to renovate past generations and this affects the future.

Lastly, according to the present structure in Castile&Leon, a sharp depopulation process in the future is foreseeable, given the low fertility rates, an aging population and increasingly more scarce female cohorts at motherhood. The migration that has affected past demographics of the region appears again as the only factor to modify the present and future situation. Only with the arrival of young emigrant population that provides births is can be the solution to reverse the depopulation process and aging population in Castile&Leon.

Table 1. Replacement index in Castile-Leon, several years

year	BRR	TFR	L^{per}	L^{coh}	BRR^{NoMig}	K^{mignet}	Births	Births by "migration"
1910	2.00	5.28	0.584	0.481	2.54	-0.21	85153	-11062
1920	1.76	4.61	0.571	0.519	2.39	-0.26	76547	-14217
1930	1.87	4.69	0.701	0.567	2.66	-0.30	80074	-19152
1940	1.74	3.37	0.713	0.606	2.04	-0.15	71010	-7400
1950	1.76	2.75	0.847	0.676	1.86	-0.05	68303	-2630
1960	1.65	3.02	0.922	0.758	2.29	-0.28	61338	-18074
1970	1.22	2.53	0.961	0.807	2.04	-0.40	41815	-22655
1980	1.04	2.03	0.980	0.902	1.83	-0.43	33168	-22755
1990	0.78	1.17	0.984	0.946	1.11	-0.30	21324	-8572
2000	0.83	1.00	0.989	0.962	0.96	-0.14	17874	-2702
2005	1.03	1.09	0.990	0.969	1.06	-0.03	19425	-548

Sources: INE. Own elaboration.

Table 2. Replacement index in Madrid, several years

year	BRR	TFR	L^{per}	L^{coh}	BRR^{NoMig}	K^{mignet}	Births	Births by "migration"
1910	2.39	4.75	0.615	0.462	2.19	0.09	25729	+992
1920	2.41	3.80	0.587	0.498	1.89	0.27	27923	+2984
1930	3.04	3.92	0.732	0.561	2.20	0.38	36373	+5618
1940	3.00	3.88	0.756	0.621	2.41	0.25	37633	+4625
1950	2.33	3.30	0.865	0.702	2.31	0.01	33479	+163
1960	3.76	2.66	0.928	0.797	2.12	0.77	59807	+20726
1970	5.39	2.91	0.962	0.842	2.45	1.20	83442	+38311
1980	3.72	2.09	0.980	0.916	1.91	0.94	72841	+32384
1990	1.67	1.27	0.984	0.946	1.20	0.39	50065	+13258
2000	1.47	1.25	0.989	0.962	1.21	0.22	56623	+9915
2005	1.77	1.38	0.989	0.969	1.33	0.33	69367	+16524

Sources: INE. Own elaboration.

Table 3. Decomposition of mothers (G_t) by place of birth (native, born in other parts of Spain and abroad) in the census years of 1981, 1991 and 2001: Castile&Leon, Madrid and Spain

	Castile&Leon			Madrid			Spain		
	1981	**1991**	**2001**	**1981**	**1991**	**2001**	**1981**	**1991**	**2001**
$\mathbf{G_t}$	16337	18107	17656	35155	39649	47474	258043	293850	327320
Total	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
$\mathbf{P^{Nat}}$	0.89	0.87	0.82	0.44	0.60	0.66	0.68	0.74	0.75
$\mathbf{P^{Esp}}$	0.10	0.11	0.13	0.53	0.36	0.20	0.30	0.23	0.17
$\mathbf{P^{For}}$	0.01	0.02	0.05	0.03	0.04	0.14	0.02	0.03	0.08

Sources: Population Census 1981, 1991 and 2001 (INE). Own elaboration.

VI. APPENDIX

Appendix 1.
Spanish map by province. Selected regions: Castile-Leon, Madrid, Basque Country and Barcelona

Appendix 2.
Estimate of births and correction of sub-register 1858-2005.

Sources:

1. Until 1946. Provisional data. Vital Statistics (www.ine.es). For particular years:
   - *Births in 1885*. Taken from: Gaceta de Madrid, 1891 N.19. Ministerio de Fomento. Dirección General del Instituto Geográfico y Estadístico (births by province and capital 1878-1888).
   - *Births between 1871-1877:* linear interpolation.
   - *Births between 1893-1899*. Taken from the Natural Migration of the Spanish Population. Year 1900. Dirección General del Instituto Geográfico y Estadístico. Total provincial data.
   - *Births between 1920 and 1930*. Calculated using birth rates per capital and province.
2. As from 1946. Definitive data. Vital Statistics (www.ine.es).

Corrections:

The records until 1950 have been corrected by using the residue calculated by Viciana (1998) and Blanes (2006). Both authors detect a sub-register in 1900 for 6% which practically disappears in 1950 after crossing registered births with censual populations and according to existing mortality conditions. The series of female births,

given that they show a higher sub-register according to these authors, have been corrected by using a sex ratio at birth of 106 boys for every 100 girls.

Appendix 3.

Estimate of the Total Fertility Rate (TFR) from 1908 to 1981 for Castile&Leon and Madrid provinces.

The calculation has been made by using the Calot (1984) interpretation of TFR as period replacement indicator: the number of women at motherhood, 15-49, has been taken from the census from 1910-1981 for each province. The female population exposure to motherhood (G_t) has been calculated by using as weighted rates the existing fertility rates for Spain in the Human Mortality Database (1971-1975) and from Festy (1979) before 1970.

Using:

$$TFR_t = B_t/G_t$$

We have calculated:

$$G_t = \Sigma\left[F_x(t)/TFR_t\right] \,.\, E_x(t)$$

The female population exposure between census periods has then been interpolated. Once the number of women at motherhood (G_t) and the number of births (B_t) for the period between 1908-1981 was known, we obtained the TFR for each province.

Using the same weighted coefficients ($\Sigma\left[F_x(t)/ISF_t\right]$) for different provinces has a very low impact on estimating G_t as can be observed below in the case of 1950 and for the entire Spanish female population. Taking the Spanish female population of 1950 and using the rural specific fertility rates (TFR=1.54) and urban specific rates (TFR=3.04) we observe how the resulting number (G_{1950}) gives a lower variation at 1%. This proves the robustness of the method and of our estimates.

	Fertility rate by age in Spain 1950			Weighted Coefficient			Female
	Total	Capital	Province	Total	Capital	Province	Population
15-19	0.008	0.006	0.009	0.0156	0.0187	0.0141	1356962
20-24	0.080	0.053	0.097	0.1646	0.1732	0.1598	1336693
25-29	0.153	0.102	0.189	0.3165	0.3318	0.3109	1208376
30-34	0.124	0.078	0.159	0.2565	0.2526	0.2605	1019221
35-39	0.083	0.050	0.106	0.1714	0.1621	0.1748	996877
40-44	0.032	0.017	0.043	0.0669	0.0548	0.0706	934664
TFR	2.42	1.54	3.04	1	1	1	
G_t 1950				***225139***	***226795***	***224433***	
Difference					0.7%	-0.3%	

Sources: Population Census 1950 and Fertility rates by age (INE)

Appendix 4.
Estimate of cohort mortality rates and period mortality rates for the provinces of Castile&Leon and Madrid, 1900-2005.

Sources:

- *Mortality tables by province* from Dopico y Reher (1998). Years: 1900-01, 1910-11, 1920-21, 1930-31.
- *Mortality tables by province* from Blanes (2007). Years: 1960-62, 1965-67, 1970-72, 1975-77, 1980-82, 1985-87, 1990-92, 1995-1997 y 2000-2002

We have taken 27.5 years as the average age at motherhood for the entire period[8].

1. *Period mortality*: Average survival to motherhood ($L^{per27.5}$)

With the tables from Dopico and Reher, the mortality rates have been obtained by logarithmic interpolation between 1900 and 1935 by year.

With Blanes' tables we have estimated the mortality rates by logarithmic interpolation between 1960 and 2005 by year.

For the period 1935-1960, they have been obtained by logarithm interpolation using previous tables.

1935-1940, affected by the Spanish Civil War: the variation in series of female mortality has been taken into account for this period (total deaths, less than 1 years old and less than 5 years from INE, Vital statistics) to correct the interpolated provincial series from 1935-1940.

Then: $\boldsymbol{L^{per27.5} = ((L^{per25} + L^{per30})/2)/ L^{per0})}$.

2. *Cohort mortality*: Average survival to motherhood ($L^{coh27,5}$)

The series of cohort mortality has been extracted from the period tables using the distribution of rates in the Lexis diagram area. Keeping in mind that the first period table is from 1900, the average survival to mortality of the cohort for 1927 has been estimated (born in 1900). A logarithmic interpolation of survival until 1908 has been made using this series.

Then: $\boldsymbol{L^{coh27.5} = ((L^{coh25} + L^{coh30})/2)/ L^{coh0})}$.

[8] Although the average age at motherhood has changed over the XX century, female survival between 25 and 35 years old is very similar given the low female mortality for this age group.

VII. REFERENCES

Agüero, I. and A. Olano Rey. (1980). "Evolución reciente de la fecundidad en España". *Revista de Investigaciones Sociológicos* 10: 121-150.

Alcaide Inchausti, J. (2003): *Evolución económica de las regiones y provincias españolas en el siglo XX*. Fundación BBVA, Bilbao.

Arango, J. and P. Martin. (2005). "Best practices to manage migration: Morocco-Spain". *International Migration Review* 39 (1): 258-269.

Barbancho, A. (1960). "La natalidad y el registro de nacimientos". *Estadística española*. 9 (Oct. - Dic.): 77-83.

Blanco, C. (1993). "The New Hosts: The Case of Spain". *International Migration Review* 27 (1): 169-181.

Blanes, A. (2006). "Las desigualdades territoriales de la mortalidad" in *Análisis Territorial de la Demografía Española. 2006*. FFAM- ICO: 181-205.

Blanes, A. (2007). *La mortalidad en la España del siglo XX .Análisis demográfico y territorial*. Departamento de Geografía. Universidad Autónoma de Barcelona. Barcelona.

Cabré, A. (1999). *El sistema català de reproducció: cent anys de singularitat demogràfica*. Barcelona, Proa.

Cabré, A., J., Moreno and I. Pujadas. (1985). "Cambio migratorio y «reconversión territorial» en España". *Revista de Investigaciones Sociológicos* 32:43-65.

Calot, G. (1984). "Une notion intéressante: L'effectif moyen des générations soumises au risque. I. Présentation méthodologique". *Population,* 39 (6): 947-976.

Calot, G. (2001). "Pourquoi la notion de "remplacement transversal" est essentielle", *Population* 56 (3): 329-331.

Calot, G and J-P. Sardon. (2001). "Fécondité, reproduction et remplacement". *Population* 56 (3): 337–370.

Carbajo Isla, M. (1985). "La inmigración a Madrid (1600-1850)". *Revista Española de Investigaciones Sociológicas* 32: 67-100.

Nadal, J. (1984). *La población española (Siglos XVI a XX)*, Barcelona, Ariel.

De Santis, G. and M. Livi Bacci. (1997). "La reproduction des populations: Une méthode de décomposition et d'estimation". *Population* 52 (5): 1119-1142.

Delgado Cabeza, M., and A. García Barbancho. (1988). "Los movimientos migratorios interregionales en España desde 1960". *Papeles de economía española* 34: 240-263

Delgado, M. and M. Livi-Bacci. (1992). "Fertility in Italy and Spain: The lowest in the World". *Family Planning Perspectives* 24 (4): 162-172.

Dopico, F. and Reher, D. (1998). *El declive de la mortalidad en España, 1860-1930*. Asociación de Demografía Histórica. Zaragoza.

EUROTAT. *Fertility rates by age 1971-2005.*

Available: http://epp.eurostat.ec.europa.eu. Data: *DEMO_FRATE:* (Age reached during the year /Fertility /Fertility rates by age/Spain).

EPA. (2005). *Encuesta de población activa*. Instituto Nacional de Estadística.

Festy, P. (1979). *La fécondité des pays occidentaux de 1870 a 1970*. Paris, Presses Universitaires de France.

Goldstein, S. and A. Goldstein. (1981). "The Impact of Migration on Fertility: an `Own Children' Analysis for Thailand", *Population Studies* 35 (2): 265-284.

Human Mortality Database (HMD). *Life tables: Spain*. University of California, Berkeley (USA), and Max Planck Institute for Demographic Research (Germany). Available at www.mortality.org.

INE. (2007). National Immigration Survey 2007. Spanish National Statistics Institute.

INE. *Births by year and region, 1925-2005*. Vital Statistics. Spanish National Statistics Institute. Available at www.ine.es.

INE. *Deaths, 1935-1940*. Vital Statistics. Spanish National Statistics Institute. Available at www.ine.es.

INE. *Fertility rates by ages and region, 1975-2005*. Spanish National Statistics Institute. Available at www.ine.es.

INE. *Population Census: 1900, 1910, 1920, 1930, 1940, 1950, 1960, 1970, 1981, 1991 and 2001*. Spanish National Statistics Institute. Available at www.ine.es.

INE. Municipal register (*Padrón municipal de habitantes 1996-2007*). National Statistics Institute. Available at www.ine.es.

INE. *Total Fertility Rates by region, 1975-2005*. Spanish National Statistics Institute. Available at www.ine.es.

Kohler, H-P., F. Billari and J.A. Ortega. (2002). "The emergence of Lowest-Low Fertility in Europe during the 1990s". *Population and Development Review* 28(4): 641-680.

Lopez de Lera, D. (1995). "La inmigración a España a primeros del siglo XX. Los que vienen a trabajar y los que vienen a descansar". *Revista Española de Investigaciones Sociológicas* 71: 225-245.

López Trigal, L. and I. Prieto Sarro. (1993). "Anotaciones a la emigración de castellanos y leoneses a Europa". *Polígonos. Revista de Geografía* 3: 163-174

Munoz-Pérez, F. (1989). "The Decline of Fertility in Southern Europe". *Population*: An English Selection 44 (1): 261-290.

Muñoz-Pérez, F. and A. Izquierdo. (1989). "L'Éspagne, pays d'inmigration". *Population*, 44 (2): 257-289.

Ortega, J. A. and J. Silvestre. (2006). "Las consecuencias demográficas de la guerra civil" *La economía de la Guerra Civil.* P. Martín Aceña and E. Martínez Ruiz. Madrid, Marcial Pons: 53-106.

Pinilla, V., Ayuda, M.-I. and Sáez, L.A. (2008). "Rural Depopulation and the Migration Turnaround In Mediterranean Western Europe: A Case Study of Aragon". *Journal of Rural and Community Development* 3: 1-22.

Preston, S.H. and H. Wang. (2007). “Intrinsic growth rates and net reproduction rates in the presence of migration”. *Population and Development Review* 33 (4): 657-666.

Ramiro Fariñas, D. and A. Sanz-Gimeno. (2000a). "Childhood mortality in Central Spain, 1790-1960. Changes in the course of demographic modernisation", *Continuity and Change* 15 (2): 235-267.

Ramiro Fariñas, D. and A. Sanz-Gimeno. (2000b). "Structural changes in childhood mortality in Spain, 1860-1990", *International Journal of Population Geography* 6: 61-82.

Rapado, J.R. (1983). “Migraciones regionales y evolución de la ocupación en España”. *Revista Española de Investigaciones Sociológicas* 22: 77-100.

Recaño, J. (2006). “Los intercambios poblacionales entre las regiones españolas” en *Análisis Territorial de la Demografía Española. 2006*. FFAM- ICO: 273-318.

Reher, D.S. and A. Sanz-Gimeno. (2000). “Mortality and Economic Development over the Course of Modernization: An Analysis of Short-Run Fluctuations in Spain, 1850-1990”. *Population Studies* 54 (2): 135-152.

Roig Vila, M. and T. Castro Martín. (2007). 'Childbearing Patterns of Foreign Women in a New Immigration Country: The Case of Spain'. *Population-E* 62 (3): 351-380.

Rodríguez Osuna, J. (1985). “Migraciones exteriores, transición demográfica y proceso de desarrollo”. *Revista Española de Investigaciones Sociológicos* 32: 27-42.

Rubio, J. (1977). *La emigración de la Guerra Civil, 1936-1939*. 3 Vol. Madrid, Ed. San Martín.

Ryder, N. B. (1997). “Migration and Population Replacement”. *Canadian Studies in Population* 24 (1): 1-26.

Sánchez-Alonso, B. (2000). “Those Who Left and Those Who Stayed behind: Explaining Emigration from the Regions of Spain, 1880-1914”. *The Journal of Economic History* 60 (3): 730-755.

Silvestre, J. (2002). Las emigraciones interiores en España durante los siglos XIX y XX: una revisión bibliográfica. *Ager nº 2, Journal of Depopulation and Rural Development Studies*: 227-248.

Silvestre, J. (2005). “Internal migrations in Spain, 1877–1930”. *European Review of Economic History* 9(2): 233–265.

Silvestre, J. (2007). “Temporary Internal Migrations in Spain, 1860–1930”. *Social Science History* 31 (4): 539- 574.

Smallwood, S. and J. Chamberlain. (2005). “Replacement fertility, what has it been and what does it mean?”. *Population Trends* 119: 16-27.

Viciana, F.J. (1998). *La transición demográfica y sanitaria en Andalucía durante el siglo XX*, Tesis doctoral, Departamento de Ciencias Sociosanitarias, Universidad de Sevilla.